Proceedings of the Technology Roadmap Workshop on **COMMUNICATION AND CONTROL SYSTEMS FOR DISTRIBUTED ENERGY RESOURCES**

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INTRODUCTION

THIS document is the proceedings of a technology roadmapping workshop to define research, development, and deployment (RD&D) needs and priorities for communication and control (C&C) technologies for distributed energy resources (DER). The workshop was sponsored by the U.S. Department of Energy, Office of Power Technologies, Distributed Energy Resources Program. A planning committee of industry, consultant, and government representatives laid the groundwork by organizing the workshop and identifying key participants. ABB, Cinergy Corp, Concurrent Technologies Corp., Energetics Inc., Pacific Northwest National Laboratory, and Sixth Dimension Inc. were part of this committee. The workshop assembled a diverse group of 43 experts representing all facets of the distributed energy community – utilities, equipment suppliers, project developers, communications and controls companies, universities, and national laboratories. Background information about the C&C roadmapping process and the objectives of the workshop can be found in Appendix A.

To provide a context for the opening plenary session of the workshop, a series of presentations provided an overview of the U.S. Department of Energy's (DOE) distributed and renewable energy programs and the role of C&C technologies. Copies of the presentations can be obtained by contacting Brian Marchionini at bmarch@energeticsinc.com. In addition, DOE's strategic goals for the Office of Power Technologies, including distributed energy and related technology development programs, were presented. Goals include lower cost, increased efficiency, modularity, increased reliability, and reduced maintenance for DER technologies. The fundamental goal is for distributed energy technologies to achieve 20% of new electric capacity addition in the United States by 2010.

Following the presentations, the overall goals of the DOE for distributed energy resources were discussed. Potential roles for C&C systems were identified. The "grand technical challenges" for C&C systems for achieving the DOE's distributed energy goals were identified. The results of this discussion is presented in Section 2.

Breakout Sessions

The workshop was divided into three breakout groups (orange, blue, and green). Each breakout group addressed four focus questions:

- What functional objectives should be established to guide distributed energy resources communications and control systems?
- What are existing technologies/tools/techniques and barriers for accomplishing the top-vote-getting functional objectives?
- What RD&D is needed to address the barriers and achieve the functional objectives?
- What is the scope, the time frame and next steps for the RD&D needs and who are the lead and supporting participants?

Appendix B provides the agenda of the workshop.

Each of the groups worked in parallel by discussing the same set of focus questions. Sections 3, 4, and 5 of this document provide summaries of each of the groups' sessions, as well as the complete tables of ideas.

Closing Plenary Session

In the closing plenary session, each breakout group presented their findings; gaps and cross cutting themes were also discussed. Section 6 of this report contains a summary of the key themes of the workshop.

GRAND TECHNICAL CHALLENGES

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WHILE promising, the future role of distributed energy systems in the U.S. economy is highly uncertain. Energy markets themselves are uncertain, particularly in light of the changes that are occurring in state, regional, and national utility regulations and environmental requirements. The Bush Administration's *National Energy Policy* identifies many national challenges in developing more energy supplies and managing energy demands and contains numerous recommendations for expanding the use of distributed energy resources. In addition, recent events in international terrorism demonstrate the need for greater security of critical energy infrastructure and facilities. In this context, distributed energy technologies, and the communications and control systems that are needed for their proper implementation, face both great opportunities ***and*** substantial technical challenges. Table 2.1 illustrates the ideas created by the group for these Grand Technical Challenges.

A critical challenge lies in the need for a more unified vision of distributed energy systems. Two alternatives have emerged that are distinct, yet intertwined. One views distributed energy systems as potentially valuable assets in operating utility systems through ancillary and demand management services. The second views them as primarily customer solutions for addressing onsite energy needs for clean, reliable power and thermal energy. Integration of these two visions could assist in the effort to determine the proper role of distributed energy systems in the nation's energy system and to build consensus as to the types of communications and control systems that will be needed.

A key aspect is the need to demonstrate the "value proposition" for distributed energy to suppliers, users, and public policy makers. A holistic analysis of the entire energy system is required to assess the full benefits of distributed energy to users, utilities, and the public at large. At this point, the structure of the market and regulations do not enable any entity to capture all of the benefits. Demonstration of a profitable business model for distributed energy providers would expand the possibilities and increase the likelihood that goals will be achieved.

Another key aspect is the need for greater standardization of communications and other protocols for the interface of distributed energy systems with other aspects of the energy system. A national "plug&play" protocol could offer users easier operations and maintenance requirements, more reliable interconnection with utility systems, and less hassle in siting and permitting. Such communications protocols could enable real-time costs of power to be translated into price signals that flow through the entire power system, thus assisting in the creation of more readily identifiable revenue streams for distributed energy systems to capture.

Table 2.1 Grand Technical Challenges

(¨ = indicates the number of votes received)

Need for a Unified Vision	Demonstration of the DER “Value Proposition”	Uniformity, Protocols, and Standards	Systems Integration	Technology Issues	Information Management
• A picture is needed of what the power systems will look like in 10 years ♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦ • National “Plug and Provide” environment which the private sector enables after basic security and safety issues addressed ♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦ • Needs to be clear and compelling ♦♦♦♦♦♦♦♦♦♦♦♦ • Coordinating complexity of local independent entities while maintaining system level reliability ♦♦♦♦♦♦♦♦♦♦♦	• Value is a function of quantity, quality, emissions, security, reliability ♦♦♦♦♦♦♦♦♦♦♦ – How to assess, measure, and communicate to users? • Need to show value streams from large scale DER deployment before specifying C&C needs ♦♦♦♦♦♦♦♦ • Regulatory and economic, not technical, issues are the primary challenges ♦♦♦♦♦♦♦♦♦♦ – Create a market with proper pricing of generation and T&D • Infrastructure for market exchanges to capture DER value streams ♦♦ • Paying for C&C infrastructure before DER resources deployed to pay for it • Showing value: explaining how US DOE C&C efforts benefit specific DER installations	• Plug&play protocols ♦♦♦♦♦♦♦♦♦♦♦♦♦♦ • Interconnection acceptance by utilities ♦♦♦♦♦♦♦♦ • Adoption DER methods, standards, protocols ♦♦♦♦♦ • Peer-to-peer communications standards ♦♦ • Data transfer and management techniques ♦♦ • Open protocols for pricing information ♦ • Inertia of existing architecture	• Systems interface tools and techniques ♦♦♦♦♦♦♦♦♦♦ • Interconnection systems ♦♦♦ • Integration of sites/buildings with process control systems ♦ • Integration of wireless and wireline communications systems for a total solution ♦ • Integration with utility system operations • Making DG part of the grid with upstream and downstream controls	• Design for manufacturing scale-up ♦♦♦ – Improving costs and reliability through mass production – Scalable controls and communications systems • Achieving user friendliness ♦♦ – Minimal learning curve – Rapid access to higher power quality/lower costs • Developing effective C&C specs – Determining where DG network gateways will reside • Increasing the reliability of distributed energy devices • Lowering the costs of distributed energy devices	• Settling issue: proprietary versus public availability of real time data ♦♦♦ • Processing massive amounts of data in real or near real time ♦♦ • Getting price signals about real energy costs to users ♦ – Sending accurate data about market conditions and prices for scheduling and dispatching DER

ORANGE GROUP

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SUMMARY

Several consistent themes were raised throughout the Orange Group's breakout sessions. One of the key messages was the need to get started immediately. For instance, to fully understand the needs for C&C systems, a large-scale DER deployment demonstration should be started soon. The demonstration would be built on two different scopes. The first would be based on a saturation paradigm in which the focus is on a community or a substation to design and implement DER. The second would be a dispersed deployment model in which DER installations over an entire region or state would be evaluated.

A technical unknown for these projects is the scale-up issue under large-scale deployment. Ultimately, C&C devices will have to operate in an open system architecture in which the systems will be "plug & play," thus allowing interoperability among many distributed energy technologies. This will make it easier for users to customize their needs by offering many viable options.

Table 3.1 Participants

NAME	ORGANIZATION
Tom Bean	Verizon
Stan Blazewicz	Arthur D. Little
Anne-Marie Borbley-Bartis	U.S. Department of Energy
Vikram Budhraja	Electric Power Group
Rolf Carlson	Sandia National Laboratory
Steve Hauser	Pacific Northwest National Laboratory
Rob Hazelbacher	Cinergy Corp.
Dave Hoffman	Celerity Energy LLC
Lawrence Jones	ALSTOM ESCA Corporation
John Kueck	Oak Ridge National Laboratory
Larry Markal	Sentech, Inc.
Anoop Mathur	Honeywell
Gary Nakarado	National Renewable Energy Laboratory
Terry Oliver	Bonneville Power Administration
John Petze	Tridium, Inc.
Mark Schneider	Sixth Dimension, Inc
Wade Troxell	Colorado State University

FACILITATOR: Rich Scheer, Energetics, Incorporated

Another main point was the importance of the Federal role when coordinating these efforts. The Federal government needs to play a large role in the areas of setting standards and infrastructure security issues. C&C is not a "utility only" problem; end users and regulatory bodies also need to be involved. The DOE is well-suited to facilitate development efforts among the involved entities.

FUNCTIONAL OBJECTIVES

Focus Question: What functional objectives should be established to guide distributed energy resources communications and control systems?

Communications and controls for distributed energy systems will have to meet a number of requirements. The architecture of the system – from control devices on individual units to communications networks linking devices to utility system operators – will need to be secure, reliable, scalable, and flexible. The system will need to incorporate market information on prices, congestion points, and peak demands. It will also need to incorporate local information on emissions, power quality, and energy costs. Embedded controls will be necessary in order to distribute as much intelligence throughout the network as possible. The system will also have to accommodate an open architecture that is capable of handling the exchange of large amounts of information. The complete list of functional objectives determined by the group can be found in Table 3.2.

TECHNOLOGIES AND BARRIERS

Focus Question: What are existing technologies/tools/techniques and barriers for accomplishing the top vote getting functional objectives?

A number of technologies are available to address the top priority functional objectives for communications and control systems. However, technical barriers exist that interfere with the ability of existing technologies to address the functional objectives today. Further research, development, and demonstration efforts will be needed. Table 3.3 is a complete record of the participant's ideas.

RESEARCH, DEVELOPMENT, AND DEMONSTRATION NEEDS

Focus Question: What RD&D is needed to address the barriers and achieve the functional objectives?

The most critical need is to conduct a large-scale demonstration of distributed energy devices in both geographically dispersed and concentrated locations. This activity will reveal weaknesses in the current suite of communications and controls systems and scale-up requirements for large-scale deployment of distributed energy devices. Other priority RD&D needs are shown in Table 3.4.

IMPLEMENTATION OF TOP PRIORITY RESEARCH, DEVELOPMENT, AND DEMONSTRATION NEEDS

Factors Considered: Scope of R&D Priority, Time Frame for Useable Results, Lead Participants, Supporting Participants, and Next Steps.

Pursuing the top priority RD&D needs will require the coordinated efforts of the Federal government, industry, national laboratories, and universities. Many of the activities need to get started right away if the goals that the DOE has established for DER are to be achieved. The top priorities are captured in Table 3.5.

Table 3.2 Functional Objectives – Orange Group

(¨ = indicates the number of votes received)

System Architecture and Functionality	Embedded Smart Controls	Networks and Communications	Security	Data Management	Automation	Costs	Users
• Sensitive to external market signals ♦♦♦♦♦♦♦♦♦♦♦ – Quantify and express local energy values – Provide “poor man’s” SCADA – Incorporate data on energy costs, power quality, system security and reliability, green power opportunities, emissions • Open Architecture ♦♦♦♦♦♦♦♦♦♦ • Follow industry standard such as IEC 61850 ♦♦ • Able to manage workflow for many users and heterogeneous devices ♦ • Provide for “plug&play” for distributed energy systems • Flexibility of solutions adaptable to market rules • Peer-to-peer system organization, discovery, negotiation, and acknowledgement • Communicate data on “global” reliability to and from DER devices	• Enable “smart” DER devices that make decisions and “learn” based on external information ♦♦♦♦♦♦♦♦ ♦ • Provide distributed devices the information they need to take action on their own ♦♦♦♦♦ • Respond to real-time data quickly and across multiple time scales	• Robust, reliable, scalable network infrastructure ♦♦♦♦♦♦♦ • Web based communications systems ♦ • Ability to connect any device offering aggregated management capability in a secure environment ♦ • Provide real-time, low-cost fully managed service network • Two-way communications flow	• A secure network of devices connected to appropriate users ♦♦♦♦♦♦♦ – Supports secure internet technologies in intranet applications – Provides system security • Reduces system vulnerability to disruption ♦♦♦	• Open information exchange capabilities to enable market transactions in public forums ♦♦♦♦♦♦♦♦ – Transparent data systems that protect privacy and security • Data exchange is accurate and quick • IT systems capable of handling 10^8 data points in real time	• Aggregate distributed devices to seamlessly interface with RTO/ISO ♦♦♦♦ • Fully automated controls at all levels • Substation automation and AMR • Ability to incorporate existing building energy management systems and utility control systems • Manage microgrids in stand alone mode as well as interfacing with utility grids	• Should be low enough for purchase under energy managers’ budget ♦♦♦ – Minimum need for project financing • Delivers SCADA capabilities for DER at costs and reliability comparable to current utility systems: <$50/kW ♦♦♦ • Provides “back office” services e.g., settlement, verification • Cost balanced with required functionality	• Users empowered to manage the system for their own needs ♦ – User interface consistent with user objectives, needs, capabilities • Regulations (local, state, Federal) transparent to user ♦ • Real time information flow on costs, quality, emissions • ISOs get access to operate grid • Web based power quality and load profile meters for use by building energy managers • Capital equipment must last 15 years, spare parts readily available

Table 3.3 Existing Technologies and Barriers to Address Top Priority Functional Objectives – Orange Group

Need for Open Architecture		Need for Open Exchange of Information		Need for Embedded Intelligence in DER		Need for Architecture that is Responsive to Market Signals		Need for Secure, Reliable, and Scalable Network Infrastructure	
Techs	**Barriers**	**Techs**	**Barriers**	**Techs**	**Barriers**	**Techs**	**Barriers**	**Techs**	**Barriers**
Aggregation of DER at substation level	Lack of unified standards e.g. IEC 61850	Internet	Weak handling large data sets	Expert systems	Not able to embed in DER devices for necessary response times	Green power programs	Not wide spread	Peer-to-peer networking	Unclear ownership and control Poorly defined value chain
		Embedded security	Sharing proprietary data	Neural networks	Lack of acceptance and knowledgeable practitioners	Emissions trading	Limited to SO_2 No value for carbon	Encryption	No standardization
				XML for data transfer	Utility industry has not defined standard formats	Real time pricing	Most at wholesale level only	Supply diversity/redundancy	Added costs

Table 3.4 Research Development, and Demonstration Needs – Orange Group

(¨ = indicates the number of votes received)

DER Demonstrations	Field Testing	Technology Development	Standards	Computer Models	Market Research
• Large scale:>5K units ♦♦♦♦♦♦♦♦♦♦♦♦ – Concentrated in certain local areas with T&D congestion problems – Dispersed across wide geographical areas – Cover mix of technologies, customer types, end uses • Smaller scale DER aggregation with DSM and renewables ♦♦♦♦♦	• Microgrids with both DC and AC ♦♦♦♦ • Applicability of IEC standard 61850 ♦♦ • Dedicated C&C test bed facility ♦♦ • Use for benchmarking, standards development, performance measurements, metrics, and information clearinghouse • Real time data capture warehouse for web-based displays ♦	• "Good Citizen" C&C system that provides PQ, no impact on relays, provides A/S, distinguishes fault from motor start ♦♦♦♦♦ – includes coordination of control and protection systems – demonstrate with stakeholders to establish value of DER • Interface device to connect DER to utility grids ♦♦♦♦♦ • Prototype of multi-agent system ♦♦♦♦♦ • Prototype Intelligent DER device using expert systems or neural networks ♦♦♦♦ • Consumer level DC system ♦♦♦♦ • Low cost, efficient energy storage device ♦♦♦♦ • Communications system for real time information on power system, PQ, dynamic reliability	• Process to eliminate barriers to open access to market transactions data ♦♦♦♦♦ • Business practice standards for interconnect, operations, market rules, environmental ♦♦♦♦♦ – PUCs – ISOs – Utilities • Process to build open architecture for plug&play and distributed intelligent controls ♦♦♦ • Standards for ISO data transfer requirements ♦♦ • Require XML-based standard for RTP feeds and tariffs ♦	• "Next generation" utility systems economics and engineering model ♦♦♦♦♦ – For system planning – Assess DER scenarios • Financial model for DER paradigm ♦♦♦ • National electricity system model to outline future vision(s) and DER impacts/benefits ♦♦ • Interactive model of peripherally controlled networks ♦♦ • Enhanced load forecasting tools ♦ – Includes DER response – Real time and long term	• Assess DER demonstration data to estimate DER value chain ♦♦♦ • Assess DER user needs for DER products/services ♦♦ • Assess user decision making for large scale DER deployments ♦

Table 3.5 Implementation of the Top Priority RD&D Needs – Orange Group

Top Priority RD&D Need	Brief Description of the Scope	RD&D Time Frame	Federal Role	Next Steps
Conduct large scale demonstration of DER and C&C systems	Saturation demo at single substation (~10MW) Dispersed demo over wide area at least 50 sites	Results needed within 3 years	DOE develops scope and design Industry cost share for equipment and siting	Charter team to develop scope Fund several conceptual designs
Conduct DER C&C field testing	Create C&C test bed for evaluating alternative architectures, standards, protocols, etc	Results needed within 3 years	DOE develops scope and design Vertical industry-lab teams compete	Survey industry and labs for test bed capabilities
Develop prototype smart DER device	Determine specs, test expert systems, and neural networks	Prototype and results needed within 3 years	DOE develops spec industry input thru roadmap	Establish working group for roadmapping
Develop C&C interface device and protocols	Single device for interface "Universal translator"	Prototype and results needed within 3 years Coordinate with large scale demo	DOE develops scope and design Development funded by industry FEMP test sites	Establish a working group to develop design and scope
Develop DER planning model	Integrated engineering-economic model for scenarios and simulations of single and multiple service areas	Results needed within 3 years	DOE and States to fund Industry/labs do development	Assess state-of-art of existing models
Establish appropriate DER C&C standards	Outline functional requirements, scope, definitions Consensus building process	Results needed in 10 years	Federal leadership (NIST?) Labs support Active industry participation	DOE establish coordinating group
Develop "Good Citizen" C&C system for DER	Detailed assessment of functional requirements Conceptual designs Field testing Demonstrations	Specs and conceptual design needed within 3 years Field testing with grid interface within 6 years Large scale demo within 10 years	Major public-private partnership DOE, utilities, manufacturers, labs, universities	Develop scope and program plan

BLUE GROUP

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SUMMARY

The Blue Group felt that the highest priority RD&D effort needed to advance DER C&C systems is a large scale field test that would be as close to real-world as possible. This project could be allied with already on-going tests; it would just require the integration of C&C devices. Data would be gathered to create information about how to work out some of the problems and achieve the best system efficiencies.

Several specific issues need to be resolved before this large-scale test can occur. For instance, if the Internet is going to be the backbone for C&C, then security will be paramount. An activity should be developed that will explore security technologies developed for Internet. The project should be started soon to determine what those security needs are, and the group should have another meeting to determine further directions.

Table 4.1 Participants

NAME	ORGANIZATION
Larry Adams	ENCORP, Inc.
Abbas Akhil	Sandia National Laboratory
John Church	Invensys Energy Solutions
Lynn Coles	R W Beck
Steve Dayney	Sixth Dimension
Jeff Hopkins	Capstone Turbine
Joe Iannucci	Distributed Utility Associates/ENCORP
Ali Ipakchi	Alstom ESCA
Kate Maracas	Motorola
Barry Peirce	American Electric Power
Mark Rawson	California Energy Commission
Mark Schneider	GS Technologies
Paul Wang	Concurrent Technologies Corporation
Steve Widergren	Battelle/Pacific Northwest National Laboratory

FACILITATOR: Ross Brindle, Energetics, Incorporated

An RD&D need that was identified is the development of a low-cost, miniature device that would be located between the distributed generation technology and the utility. This black box, chip, or board would be a watch-dog device that would provide security and a standard set of algorithms and relay functions. The incorporation of this device would encourage smaller companies to get involved.

The interface with the grid is another fundamental issue that must be solved. A project should be started to look at open architecture allowing for "plug & play" interoperability. Unless these systems start using the same interface, then market penetration will be limited because the systems will be costly and inflexible, thus eliminating many potential customers.

RD&D will require leadership by industry, the Federal government, and universities, and these activities need to get started right away if the goals that the DOE has established for DER are to be achieved.

Modeling was seen as a necessary component since it is not feasible to field test everything. Economic modeling that clearly states value propositions must be done. There is also a basic short term need to determine functional objectives. Currently it is not possible to defend a unique set of functional objectives for the next decade. However, common objectives and limits can be deciphered if several future scenarios are analyzed. It will be important to look at different combinations of functional objectives that arise when this scenario analysis is completed. Table 4.2 provides the framework for this analysis.

FUNCTIONAL OBJECTIVES

Focus Question: What functional objectives should be established to guide distributed energy resources communications and control systems?

Defining functional objectives for distributed energy resources in the energy industry is an ominous task in light of the uncertainty regarding the future (as described in the Grand Technical Challenges section of the report). Two of the most critical issues that require resolution are the point of control of DER and the data flow/management associated with potentially tens of thousands of DER units. Utilities are reluctant to give up any control over the power system to distributed resources due to security and safety concerns. However, they cannot process the data generated by monitoring the operation of all DER units in real time. There are several likely scenarios. Those scenarios are depicted in Table 4.2 below.

Table 4.2 Distributed Generation Scenario Matrix

Future Structure of Power System	DG USERS WHO PREDOMINATE		
	Customer Dominance	Utility Uses (T&D, etc.)	ESCO lead (aggregators)
Utility command and control			
Islands of DG			
Optimal DG integration and mutual reliance			
"Anarchy"			

The row headings of this matrix represent the future structure of the power system and progress from totally centralized utility command and control to completely non-centralized control or "anarchy". The column headings represent the way in which DG is used in energy markets: customer use, utility use, or in-between use by aggregators.

To establish useful functional objectives, one approach is to **consider these different scenarios to determine which are most likely and then develop functional objectives for each scenario**. One popular view of the future is a distributed architecture **approach**, in which aggregators share necessary information with the utility to enable them to maintain overall power system integrity while shielding it from massive amounts of data. Such an approach depends on **distributed intelligent C&C systems that can make decisions independently of utilities** when those decisions do not impact overall power system operation.

In order for such an approach to be effective, **understanding the parameters for operating DER systems as they affect power system reliability, security, and energy market economics** must be thoroughly understood. Once understood, they must be monitored and controlled to ensure optimum power system performance. Including energy market economics will allow DER users to take advantage of changes in prices in real time, thus maximizing profits in a dynamic energy market. The group's list of functional objectives are found in Table 4.3.

TECHNOLOGIES AND BARRIERS

Focus Question: What are existing technologies/tools/techniques and barriers for accomplishing the top vote-getting functional objectives?

A number of technologies are available to address the top priority functional objectives for communications and control systems. However, technical barriers exist that interfere with the ability of existing technologies to address the functional objectives today. Table 4.4 shows that further research, development, and demonstration efforts will be needed for internet security, scalable protocols, transmission and distribution, local distribution control strategies, and several other areas.

RESEARCH, DEVELOPMENT, AND DEMONSTRATION NEEDS

Focus Question: What RD&D is needed to address the barriers and achieve the functional objectives?

To meet this uncertain yet promising future for DER, a wide range of research, development, and demonstration is needed to advance C&C technologies. Effective C&C technologies are essential for DER to gain acceptance in the energy market, particularly with utilities. The RD&D can be organized into six areas:

- System Reliability
- Modeling
- Identification and testing of key input parameters
- Use of Internet
- Distributed Architecture
- Integration of Market (Economics and Physical)

Several RD&D needs have been identified in each of these areas (see Table 4.5). The top-priority needs are described in further detail below.

A **real-world field test of C&C systems** is the highest priority R&D effort to advance DER systems. Such a field test should incorporate many distributed generation units, including several diverse technologies, to produce multiple MWs under real-world distribution situations. Because these systems are relatively new, utilities are wary of the effect they may have on overall power system reliability, quality, and economics. A field test of this nature can help convince utilities and other key stakeholders that DG technologies can operate safely, securely, and cost-effectively to improve the overall power system. A field test of this nature can also help provide knowledge of how changes in communication standards can influence market economics by experimenting with different standards and observing their effect on the market. Because utilities may be reluctant to conduct this sort of test on actual operating systems, simulation testing should be done as a first step. Ultimately, however, the C&C systems must be tested on real, operating systems for the test to gain validity.

In the System Reliability area, the highest-priority R&D need is achieving **interoperability and conformance between legacy and new DER systems**. The massive investment in legacy equipment throughout the energy industry in the United States will remain a vital part of the power system for decades. Any new DER systems brought into the power system will have to communicate and operate with these legacy systems. C&C systems that are designed to integrate the legacy and DER equipment will be the ones that gain ultimate acceptance and use in the power system.

In the area of Modeling, the highest-priority need is **economic models that quantify the value propositions of DER**. Such models should include voltage support, reserve offsets, reliability, and other factors that determine how DER can offer value to the power system. Quantifying these benefits will provide information needed to encourage investments in distributed systems. Demonstrating the value propositions of DER to suppliers, users, and public policy makers is cited in the Grand Technical Challenges section of this document as one of several key challenges. This research effort is aimed at meeting that challenge.

Using the Internet as a communications backbone for communication and control for DER is the most likely scenario because it is already in place. While some within the energy industry cite security and reliability concerns, establishing a separate backbone for exclusive use with C&C DER systems would prove a costly endeavor. Combining Internet C&C techniques with distributed architecture of intelligent systems capable of making decisions in the event of momentary interruptions may be the most cost-effective and realistic scenario. To that end, the two top-priority needs in this area are **analyzing existing Internet security systems** to determine their usefulness for DER C&C purposes and **developing a "plug and play" standard for C&C of legacy and new devices**. Understanding what is available and establishing a standard are critical steps. An analogy to high-definition television (HDTV) is appropriate. HDTV was largely a failure because a common standard was not established, creating an environment of conflicting technology and confusion among consumers. DER can learn from that failure and not repeat its mistakes.

IMPLEMENTATION OF TOP PRIORITY RESEARCH, DEVELOPMENT, AND DEMONSTRATION NEEDS

Factors Considered: Scope of R&D Priority, Time Frame for Useable Results, Lead Participants, Supporting Participants, and Next Steps.

Eight of the highest-priority RD&D needs have been further analyzed to consider the scope of the effort needed, the time frame for useable results, lead participants, supporting participants, and next steps. The details of this analysis can be seen in Table 4.6.

Some general themes can be seen across the top-priority RD&D needs. Most of the R&D priorities considered involved a government-industry partnership, with a shared lead in many cases. DOE and national laboratories were cited as specific government parties which should participate. All of the R&D priorities were expected to yield useful results in the near- and mid-term. Five of the eight priorities analyzed would provide benefits in one year, while the furthest-reaching needs would be on a three-to-five-year time frame.

Table 4.3 Functional Objectives – Blue Group

(¨ = indicates the number of votes received)

Information Flow and Management	Markets and Prices	Robustness and Reliability	Institutional	Programmatic Goals
• Move from centralization command and control to local, distributed intelligent control strategies (remove communication pathway load, filter information) ♦♦♦♦♦♦♦♦♦♦ – Need data compression and intelligent algorithms that reduce amount of data transmitted over networks – Intelligent, autonomous decision-making capability to reach to market signals (price, cost, environment distribution operations) – Autonomous and aggregated control capable (flexible for central and de-centralized control) • Make decisions on key information flow factors: ♦♦♦♦♦♦ • Backbone (Internet, other) • Control point (peer-to-peer, third party, utility) • Open peer-to-peer communication standards ♦♦♦ • Integrate natural gas infrastructure to avoid just shifting demand ♦♦ • Develop capability to interact with environmental aspects (e.g., deploy for NOx on non-attainment days) ♦♦ • Reduce response time for automatic gas control • Know everything about everything, (neighbors, grid, cost); in real time calculate everything, control everything • Define layers of ISO network and define interfaces among them and standards • Hierarchical control architecture with scalability/ compatibility with legacy systems	• Communication must embrace price signaling (transparent) ♦♦♦♦♦♦ • Perform matrix analysis of possible future scenarios (users and control configurations) and attempt to determine those most likely (see matrix in text), determine functional objectives for those scenarios ♦♦♦♦♦♦♦ – Look for areas of C&C technology development that are independent of political, regulatory, market, etc. uncertainties • Optimize (on a cost/performance basis) the integration of DER into power systems of the future ♦♦♦ • Decrease the cost of operation and increase the reliability of DER devices in order to create a sound business model ♦♦ • Interact with power market, transmission, distribution, customer ♦ • Increase DER value propositions, DER power quality, DER T&D reliability ♦ • Enhance DER models and simulation of DER scenario impacts • Regional power market, bid to hourly, daily, day-ahead prices • Use DER to reduce distribution costs: – UAR – Distribution peaking – Islanding • Use DER to reduce transmission costs: – LMP – Flowgate prices – Ancillary service	• Understand parameters for operating DER while addressing power systems reliability, security and, energy market's economics ♦♦♦♦♦♦♦♦♦ – Need to first define C&C requirements for different entities, then develop tools and techniques • Develop graceful failure scenarios, localize problem, preserve system ♦♦♦ • Security: more than just firewalls and role authorization, leverage existing communication infrastructure (e.g., Internet) to keep costs low • Increase reliability of the distribution grid by performing real-time or near-real-time predictive maintenance • Ensure cost effective, reliable, user-friendly, safe C&C systems	• Remove artificial barriers, prove safety and management capabilities with C&C, and allow market to determine economics ♦♦♦♦ • Soften barriers that may exist from utility system (T&D) operators – Both regulatory and operational barriers ♦♦♦ • Treat DER other loads are treated: not directly controlled by utilities ♦ • Electrical characteristics of the grid are changing, changing protection, relaying, and control – C&C will need flexibility to adapt • Facilitate utility embrace of DER with better temporal, spatial cost models • Develop capability to be integrated (control wise) with distribution system protection devices	• Demonstrate large scale (> 500 device) network of multiple DG types ♦♦♦♦♦♦♦ • Reduce cost to of C&C systems to 100x lower than existing centralized systems on a unit basis • Scalable, massive rollout requires pervasive and reliable architecture, not client server • Outperform current systems in terms of power quality and cost, and achieve a supply/demand balance • C&C systems provide enhanced performance to system rehabilitation, (25% over 2000 levels) • Optimize control of aggregated operation of multiple DERs for a combined capacity of 10 MW by 2010

Table 4.4 Existing Technologies and Barriers to Address Top Priority Functional Objectives– Blue Group

(¨ = indicates the number of votes received)

Establish the communication backbone to be used and decide on control point	Graceful failure mechanisms	Evaluate the impacts on C&C functional objectives on the underlying (1) power system structure and (2) major DER market participants (a matrix), search for common functional objectives	Communication must embrace price signaling in a transparent manner	Move from centralized C&C to local, distribution, intelligent control strategies (autonomous decision-making)
• Dedicated systems, phone internet, radio local only • Use Internet with DOE standard for security; Intranet: minimum standard protocol for safety that all can agree to • Barriers: perceived safety and reliability issues, non-central control • Scalable protocol that can be used for all complexity levels, size is a difficult issue – There are minimum safety levels that can be agreed upon	• Current technology: Internet for some applications and for communication server failures; can use existing transportation control isolation schemes • Proactive monitoring and tools/techniques proceeding to respond to failures • Barriers: Requires mind-share on a distributed architecture • Localized failure tolerated to protect system level reliability • Local intelligence for independent operation under communication failure • Barriers: lack of simulation, need demonstrations, understanding of distributed architectural approach • Interconnection standards require costly equipment, process (direct proportion with the unit's impact on system)	1. Functional objectives; what information types, to whom, accuracy, speed, for what decision; cost/ effective, reliable, compatible, open architecture security 2. Problem; at this point no one can set and defend a unique set of functional objectives for the next decade 3. Solution; (1) analyze 12 equally likely futures to: a) determine bounds on objectives, b) search for common objectives in priority order, (2) suggest bellwether events to help select likely futures and hence objectives	• Power supply: pool dispatch, phone calls, fuel (contract or phone), tariffs, "TOU" • Transmission: ISO-TCP/IP, long-term contract, non-firm daily (phone) • Distribution: tariffs, contracts, load management • Power supply: number of units, need to share pricing signals in market, bid acceptance information, real time fuel price • Transmission: bid acceptance for constraints, number and location is a barrier, distribution-not "site" volume priced • Mega RTOs are now planning new schemes, DER is not part of this process due to small size	• Existing technologies, achievable today on a customized basis • Parameters, signals, real-time pricing (tariffs, infrastructure), real-time consumption, demand, environmental, regulatory, stability • Needs/Issues, quality and reliability of 2-way information, process for establishing control parameters/signals

Table 4.5 Research Development, and Demonstration Needs – Blue Group

(¨ = indicates the number of votes received)

System Reliability	Modeling	Identification and Testing of Key Input Parameters	Use of Internet	Distributed Architecture	Integration of Market (Economics and Physical)	Other
• Interoperability with conformance among legacy and new DER systems ¨ ¨ ¨ ¨ ¨ ¨ ¨ ¨ ¨ • Understand impact of DER on power systems reliability, AGC, voltage control, stability, power quality etc. ¨ ¨ ¨ ¨ • Conduct functional objective "matrix analysis" of future situations (near-term) ¨ ¨ ¨ ¨ • R&D on control strategies and technologies in micro grid structure where voltage and frequency control is not grid supplied • Dynamic analysis of high-penetration DER systems to develop communications requirements • Ensure the safe integration of DG devices in order to protect the people maintaining the grid	• Develop economic models to quantify DER value propositions (voltage support, reserve offsets, reliability, etc.) ¨ ¨ ¨ ¨ ¨ ¨ ¨ • Modeling and verification—operational, planning/design, economics, security, electrical (dynamic, imbalanced) ¨ ¨ • Aggregate environmental impact simulations and communication needs required to maintain regional caps ¨ ¨ • Decision-making tools (CAD/modeling/ simulation) to optimize the design and operation of aggregated DGs to meet individual user needs ¨ ¨ • Simulation of the impact of various market-based signal approaches on the control of DER • Conduct system modeling among DER as a load on the grid and an important supply (grid stability)	• Field test for controls: ¨ ¨ ¨ ¨ ¨ ¨ ¨ ¨ ¨ ¨ ¨ – Diverse technologies – Many DG and multiple MWs – "Real world" distribution situations (near-term) • Full-scale, real-world demonstrations with sensitivity to understanding how comm. standards impact the market organism ♦ – Simulation is important first step	• Analyze available Internet security standards, tests "COTS" ¨ ¨ ¨ ¨ • Standard development for C&C of legacy and new devices using TCP/IP – Learn from HDTV ¨ ¨ ¨ ¨ • "Black Hat" communication and control security attack (long-term)	• Determine minimum standard for safety and communication ¨ ¨ ¨ • Low-cost, miniature device for integrated operation of sensing/ communication/control ¨ ¨ ¨ – To enable local decision-making based on information • Control schemes can be pushed down to buildings, residences ¨ • Determine when peer-to-peer local or remote "central" control is most appropriate • Look at hybrid car to offer DG of individual residence and controls • R&D of C&C devices that are flexible such that they function in central or decentral control structure (i.e., bridging opportunities that minimize risk of becoming obsolete) • Evaluate ability to have intermittent and constant sources interact to be more cost-effective than either alone	• Impact of DER on energy and AIS markets (LMP) simulation studies ¨ ¨ ¨ • Confirm viability of DG for transmission constraint relief ¨ • Develop electronic regional market for all players ¨ • Develop a "pro for ma" distribution tariff • Look at vulnerability of natural gas reserves and transmission capability	• Design of distribution systems should possibly be modified to be DER friendly – e.g., placement of cap sources • Inexpensive sensors—emissions, faults, PQ, meters

Table 4.6 Implementation of the Top Priority RD&D Needs – Blue Group

RD&D Priorities	Scope	Timeframe	Lead Participants	Supporting Participants	Next Steps
Real-world field tests of C&C for (1) diverse technologies, (2) many DGs, (3) multiple MWs, (4) real-world distribution situations	• Various distribution systems (radial, looped, network) • Deep penetration (>> 20%) • Commercially available DG technologies (inverter and non-inverter based) • Control scenarios • Central power cont • 3rd party aggregates • Industrial/owner • Distribution open cont • Others – Need participation from real utilities, ultimately multiple real utilities – Advisory group, volunteer agencies by DOE in conjunction with IEEE, DG industry organizations • Information needs/inputs • Status of units • Raise signals • Emission limits • Fuel center/availability • System emergency status (blackouts) • Local load information balance • Model and model verification ASP	• Near-Term	• DOE • National Labs	• States, industry, utilities	• Create national C&C demonstration advisory team • Develop C&C text plan • Select/design C&C software/hardware

Table 4.6 Implementation of the Top Priority RD&D Needs – Blue Group

RD&D Priorities	Scope	Timeframe	Lead Participants	Supporting Participants	Next Steps
Interoperability and conformance with legacy equipment and new DER systems	• ID new standard that best supports distributed architecture and create optimized migration path for legacy systems – As opposed to one system that can handle all legacy equipment, too expensive – One approach is a front-end gateway model, translation device – Objective is to get legacy systems into DER market, several ways to do it, this helps – Put burden back onto the legacy systems if they want to get into market – The (who) controls is important. Aggregator not instead of utility? Need minimum safety requirement for utility to feel comfortable	• Near-Term	• Government, Industry, and IEEE	• Utilities	• Assess existing base • Develop new standard requirements • Prioritize/optimize legacy migration and new software
Economic models to quantify DER value propositions (voltage support, reserve offsets, reliability, etc.) **Impact of DER on power system reliability AGC, voltage control, stability, PQ, etc.**	1. Voltage support (TR and distribution) 2. Frequency regulations and load following 3. Customer reliability and power quality 4. Distribution reliability (island operation) • Operating models for each function requirement, dynamic, static (use existing, commercial models, modify for DER) • C&C role, need to understand economics/ value to determine whether use is needed and to what extent • Economic models, site specific data, validation, field demonstration (hardware) – Classical tools exist, need DER modules to modify (near-term) – To-do phase imbalances, etc., need new models 1 to 2 years	1. Functions, technical match (2 to 3 months) 2. Operating models 6 to 9 months 3. Eco models 6 to 9 months 4. Field validation 1 to 2 years	• Functions • Utilities, coops, large/ small, ISO, RTO, users moderated by government • Technical Match • Original group and equipment experts (prime movers, 6th dimension, Encorp and power elect, traces, ABB • Operating Models • RW Beck, PTI, GE, ABB and Power system • Economic models consultants, utilities, coops, vendors	• CEC, NARUS, NRECA, EPRI, APPA, ISO, RTOs	• Field demonstrations • Contracted analysis • Commercialization

Table 4.6 Implementation of the Top Priority RD&D Needs – Blue Group

RD&D Priorities	Scope	Timeframe	Lead Participants	Supporting Participants	Next Steps
Conduct R&D to analyze current Internet security standards, test "COTS"	• Determine requirements, low cost at DG node, small footprint at DG node, multi platform, high security • Evaluate existing technology • Present to workshop for discussion and recommendation • Identify and close gaps • Field test simulation	• Complete in 1 year, near-term	• University lead Industry support validation – For universities objectivity, need industry buy-in	• University • Industry	• Assign to university/lab to begin process
Determine minimum standard for safety and communication of distributed architectures	• Develop standards and guidelines for C&C fault tolerance and inter-device behavior schemes – Ability to allow overseeing entity to have ultimate control for safety reasons	• Within 5 years	• Industry for ultimate acceptance	• Universities and National Labs	• DOE issue RFP or host workshop to scope project
R&D need plug 'n play connectivity standard	• Standards communication, interfaces, protocols, security, information, methods. plus others as required	• Near-Term: ID existing • Mid-Term: Develop interface with existing methods • Long-Term: New standard	• Industry OEMs	• Utilities • Labs • Universities	• Inventory of existing connectivity methods/ standards • Determine desire by industry for such plug-play connectives
Conduct functional objective matrix analysis of future situations	• Need: Prioritize functional objectives • Approach: Scenario analysis (1) multiple power system futures (2) customer, utility, aggregator DG implementations	• Immediate FY02	• DOE • National Labs	• DG industry • C&C • Utilities	• Develop strawman assessment • Workshop to build on draft assessment and project functional objectives • Final report including industry inputs
Low-cost, miniature device for integrated operation of sensing, communication, control	• Specify input/output function for device that provides protective relay function, communication/security function, fuel supply, single chip digital device, "watch dog processor" low cost • Determine design, single chip, board level, box level • Produce prototype, test/evaluate • Develop commercial plan • Meet industry standards	• 3 to 5 years	• Labs • Industry		• DOE-funded proof of concept

5

GREEN GROUP

SUMMARY

Several main points were emphasized by the Green Group including the funding of infrastructure projects. An infrastructure needs to be in place to give a context for the market. This sets the stage for multiple DG technologies to play out. These technologies exist today, but there is a need to be able to coordinate and tie them together.

The notion of scalable systems was also important. These systems need to be able to suit multiple users' needs in order to reach an acceptable level of market saturation. However, to be scaleable the products must first be economically viable. These systems need to be at the level of 1000+ units and the question is how one does it.

Leadership is needed to set performance measures and to synchronize efforts among the involved parties. DOE should be the catalyst that puts a stake in the ground for industry and academia to strive for. DOE should also be the focal point for Federal and state interaction.

In addition, models are needed to support the development of regulatory policies. Regulators should be given the right modeling tools to help make decisions. There are environmental issues from rolling out DG from an air quality perspective. A portfolio approach must be taken where DG is shown as a whole that is moving in the right direction.

Table 5.1 Participants

NAME	ORGANIZATION
Jim Bacchus	DG Interconnect
Sunil Cherian	Sixth Dimension
Michael Doucas	Engage Networks
Michael Dvorsky	Caterpillar, Inc.
George Hernandez	Enron
Marija Ilic	Massachusetts Institute of Technology
Carl Imoff	Battelle
Rick O'Connell	Motorola
Karl Rábago	Rocky Mountain Institute
Stephen Rassenti	Automated Credit Exchange
Jim Torpey	GPU Engineering
Ken Wicker	E Source

FACILITATOR: Jennifer Miller, Energetics, Incorporated
NOTE TAKER: Brian Marchionini, Energetics, Incorporated

FUNCTIONAL OBJECTIVES

Focus Question: What functional objectives should be established to guide distributed energy resources communications and control systems?

By definition (as provided by the steering committee) functional objective means: quantifiable service or performance attributes that are needed for DER technologies to operate properly, thus achieving the DOE stated goals. This group agreed that two assumptions must made prior to responding to the focus question:

1. There is sufficient penetration of DER to meet DOE's goal of 20%.
2. DER is a financially viable industry

These assumptions were maintained throughout the remainder of the workshop.

One participant presented the "Nine Laws of God," which were quickly accepted by the remainder of the group:

1. Distribute being (spread into different areas)
2. Control from bottom up
3. Cultivate increasing returns
4. Grow by chunking
5. Maximize the fringes
6. Honor errors
7. Pursue no options, have multiple goals
8. Seek persistent disequilibrium
9. Change changes itself

The ideas generated by the group were separated into four different categories: inherent technical/operation attributes, open architecture/platform issues, market interaction, and next generation control paradigm/core values. Table 5.2 lists the functional objectives, as defined by this breakout group, sorted by category. Some objectives carry implications that overlap into other categories; this is represented by a number in parenthesis following the objective.

All participants agreed that all the tools for C&C technologies/systems are already created; the major obstacle is that utilities are not willing to "play ball" by relinquishing access to the meter – which makes penetration of DER difficult. Utilities continue to use the argument that, in order to maintain a safe and secure power line, they need absolute control. The group took this knowledge under consideration and agreed that if the DOE goal of 20% DER penetration is to be reached, future C&C systems must be secure and adaptable to individual customers and to service provider security protocols. Additionally, in today's world, while the C&C technology exists, the systems need to be custom built to suit the needs of the individual customer. Future C&C systems must be modular, as it is essential that they be affordable, flexible, and functionally stackable so that customers, including industry, utilities, and private citizens, can purchase these systems "off the shelf." A third functional objective receiving support is to standardize the transaction management system and include a "historian" that would capture all transactions, providing a tracking mechanism for load transfer.

TECHNOLOGIES AND BARRIERS

Focus Question: What are existing technologies/tools/techniques and barriers for accomplishing the top vote getting functional objectives?

The participants agreed that no new technologies or barriers exist that would prevent accomplishing the objective of creating a secure, adaptable C&C systems for individual customers and service providers. However, a leadership void which prevents this technology from being utilized does exist.

Cost was identified as a barrier inhibiting modularizing C&C systems, as multiple vendors exist and it is expensive to create a device that will allow all the available products (e.g., SCADA, field bus) to communicate with each other. Unless this barrier is overcome, the marketability of C&C systems will be limited.

Standardizing transacting management first begins with standardizing the data between all connected systems. Additionally, in order to have an effective management system between DG and its user, the utilities need to allow the C&C systems access to both the meters and the power lines.

Additional technologies and barriers can be found in Table 5.3.

RESEARCH, DEVELOPMENT, AND DEMONSTRATION NEEDS

Focus Question: What RD&D is needed to address the barriers and achieve the functional objectives?

As emphasized in prior sessions and in Table 5.4, the primary focus for RD&D in C&C systems is on standardizing the protocol needed for transacting distributed generation. Unless these systems start using standardized interfaces, market penetration will be limited, as the systems will be costly and inflexible, thus eliminating many potential customers.

IMPLEMENTATION OF TOP PRIORITY RESEARCH, DEVELOPMENT, AND DEMONSTRATION NEEDS

Factors Considered: Scope of R&D Priority, Time Frame for Useable Results, Lead Participants, Supporting Participants, and Next Steps.

The top priority RD&D needs, as shown in Table 5.5, will require leadership by industry, the Federal government, and universities. These activities need to get started right away if the goals that DOE has established for DER are to be achieved.

Table 5.2 Functional Objectives – Green Group

(¨ = indicates the number of votes received)

Inherent Technical/Operation Attributes (1)	Open Architecture – Platform Issues (2)	Market Interaction (3)	Next Generation Control Paradigm/Core Values (4)
• Durable (MTBF), serviceable (turn-around), self-healing (system integration), condition signaling ♦ • AGC – like dispatch ability for "meaningful" amounts of DR in 15 second to 3 minute time slice ♦ • Conduit for non-power related information (customer data) ♦ • Security curtailment, safety curtailment, communication protocols • Fault tolerance failure in DG or C&C ♦ • Common protocols for diagnostics to help owners & security managers assess availability ♦	• System integration of networked DER with utilities • C&C systems must be secure and adaptable to individual customers & service provider security protocols (4) ♦♦♦♦♦♦♦ • A multi-time scale C&C system will ensure/facilitate a DER/customer transaction implementation and communicate time/IO ♦♦ • Protocols must be open and standards published • "New" dedicated communications infrastructure • Link distribution of wholesale technical/economic processes • Dynamic reconfiguration of DER network structure (1&4) ♦♦♦ • Real time and near-real time C&C platform, as industry moves towards RTP (3) ♦♦♦♦♦ • Standardize utility meter interface ♦ • Automate process – the ability to aggregate energy loads over multiple locations and bid into capacity markets and end-user benefit	• "Non-repudiation" R&D on E-Tech's App. 5 (security) of utility as it applies to DG transaction and generation • Interface with existing (legacy) systems (2) ♦ – Address utility fears of islanding • Dispatch confirmation available to markets & security functions (ISOs, etc.) ♦♦♦ • Testing – making sure products are ready when market is accepting • Information switching (open access) (2) ♦♦♦♦♦ • "Timely" feeds for real time pricing • Interval data requirements differ between ISO and utility for financial reporting • Standardized transaction management system/historian ♦♦♦♦♦♦♦♦ • Standard metrics for DER to operate against (2) ♦	• "Timely" detection, control for disaster recovery & outage notification ♦ • Long-learning agent National registration and C&C for security and operations leading to grid "self handling • C&C systems must be affordable, flexible, and functional stackable (1) ♦♦♦♦♦♦ • Look to other countries for examples (i.e., Germany) • Generalizing C&C in large scale – going beyond traditional (2) • Simple, clean, diffusible (non-redlining)

Table 5.3 Existing Technologies and Barriers to Address Top Priority Functional Objectives – Green Group

C&C Systems Must Be Secure & Adaptable to Individual Customer & Service Provider Security Protocols		C&C Systems Must Be Affordable and Functionally Stackable And Flexible		Standardized Transaction Management System/Historian
Technologies/tools/ Techniques	**Barriers**	**Technologies/tools/ techniques**	**Barriers**	**Overarching comment: Standardization of Data**
• No new technologies needed • Technical barriers do not exist • Communication technology is there (from paging to TCP/IP) • Creation of a secure network that can operate through a breech	• Leadership void does exist • If no tired approach – non generation / Adapt to appropriate user or provider	• Mature C&C systems for CSOM operation (manual, BCS/Energy Management Control System) • SCADA systems • Field bus (modbus) • Systems integration • Market "isolation" – Not many markets open for DG access – C&C simplistically manual • Outside-the-meter systems just emerging. Current applications limited in scale. Interoperability very limited	• Adding new functionality to legacy systems is costly • Lack of device interoperability • Integrating systems from multiple vendors is difficult/costly • Ability to add functionality incrementally is very limited • Ability to stock functionality from multiple vendors economically • Backend integration with enterprise software – billing, SCADA, etc. • Ability to take info from markets and integrate automatic logic for DER participation is missing	• Meters - Technology exists – Barrier: Utility won't allow access • Technology – Internet – Barrier: Internet is imperfect • Technology – Power line carrier – Barrier: Need participation by utility – Barrier: Questionable market penetration

Table 5.4 Research Development, and Demonstration Needs – Green Group

(¨ = indicates the number of votes received)

Large Scale Demos (1)	Standardization (2)	Legislative/Regulatory Policy (3)	Modeling (4)	Hardware/Software Systems Development (5)
• National/regional device database (XML & E-tag V1.7) • Demonstrate a C&C system on a large (e.g., 50 MW, 1000 customer) DER network will value capture of customer, wholesale, ancillary services & wires benefits ♦♦♦♦♦ • "Emergency Broadcast" turn on & security curtailment broadcast experiments (e.g., order shutdown by device – 1000 devices)	• Contractual arrangements that will optimize speedy adoption of DER • Standard protocol development for transacting DG ♦♦♦♦♦♦♦	• Utility meter access for settlement ♦♦ • A new regulatory & utility revenue model for a high penetration scenario ♦♦♦♦ • Emissions modeling impact on realistic penetration ♦♦ • What system wide information should be commonly available to all market participants to encourage DER adoption ♦♦	• Comprehensive assessment of the status quo • Strategies for effective automated utilization of DG capacity (1) ♦ • Modeling & simulation tools to evaluate threat scenarios, disruption contingency, & circumvention ♦♦♦ • Models of how to manage C&C systems in deregulated environment • Reference model of "ideal" future energy network with clearly defined guiding principles (open architecture, competitive, robust market mechanisms for value streams) ♦♦♦ • Develop financial modeling tools ♦♦♦ – "Next generation" public domain distribution system modeling software benefits & costs • Impact of "significant" DG capacity on power network stability ♦♦ • Empirically based commercialization scenario analysis (with improvements over current EIA approach) ♦ • New energy technology integration of DER long-term to create "virtual utilities" and reduce dependence on power plants • Develop experimental market simulations to test regulatory structures that support 20% DER penetration scenario ♦♦♦ • International market opportunity analysis ♦ • Human resource requirements (regulatory, industry, support industry) in a high penetration scenario	• Breakthrough "cheap" sensors and communication for intelligent DR/load manufacturing ♦ • IT data structures for fully transparent market place & physical management of the gird ♦ • What are limits to RT control/self-healing networks? ♦ • Power line carrier technology for C&C in a broad scale implementation ♦♦♦ • Support R&D for cheaper paralleling switchgear with intelligence communication capability ♦♦ • Research interconnection issues and reduce cost of interconnection equipment hardware – affordability of DER • Analysis tools (system models) that enable quantification of temporal & locational value of DER ♦♦ • Reducing emissions of emerging DG systems • Creation of seamless & secure (DER) network – network architecture must be scalable and cost effective with longevity ♦♦♦ • Inverter, etc. development for 10 kW to 1 MW range • "Low cost connection" (e.g., <30 kW) fun device creation • "Electron tagging" technology applied to DG assets to determine source of energy • Power electronics level solutions that integrates power switching with system wide information • C&C needs for non-electrical DER (H2, natural gas) ♦ • Support R&D of cheaper more functional interval meters • Include emissions as part of C&C system ♦♦

Table 5.5 Implementation of the Top Priority RD&D Needs – Green Group

RD&D Needs	Brief Description of Scope of the Need	Time Frame	Lead Participants	Supporting Participants	Next Steps
Power line carrier technology for C&C in a broad scale implementation	Assessment of existing PLC technology with regard to: • Performance • PLC network architecture • Economics • Ownership of wires	Near term (0-5 years)	Industry	• Transmission distribution companies • Technical vendors in this area	• Broad agency announcement (Pre-RFP) • RFP
Creation of seamless & secure (DER) network – Network architecture must be scaleable & cost effective with longevity	Creation of seamless, secure, scalable, cost-effective network that enables communication of data and commands to/from DER	Mid-term (5-10 years)	Government	Industry	Recommendations and validations of need (feasibility study)
Develop experimental market simulations to test regulatory structures that support 20% DER penetration scenario	Develop experimental economic models and tools to stimulate DG and encourage proper public policy	Near-term (0-5 years)	Government closely followed by university	Industry steering "got to settle"	• Survey of existing tools • Determine program • Diffusion funding from DOE
Develop financial modeling tools	• Ability to model value to participants based on strategic interactions between free market participants • Compare and contrast stranded asset model with high DER penetration model	Near-term (0-5 years)	University	All stakeholders	• Define team of stakeholders
Modeling and simulation tools to evaluate threat scenarios, disruption contingency, and circumvention	• ID likely threat scenarios • Quantification of positive and negative impact of DER on threat • ID's technical regulation in C&C • Allows model to run State by State	Development – Near-term (0-5 years) Diffusion – Mid-term (5-10 years)	Government – OPT work with NREL	• NERC • OHS • FERC • NARUC	• Let "realism" contract to develop DG to scenario
A new regulatory and utility revenue model for a high penetration scenario	• How can utilities make money under high DER penetration – cost to serve profitability models	Near-term (0-5 years)	Universities	• Government (National Labs) • ESPs • Utilities • PUCs • NARUC	• Define team with stakeholders represented

Table 5.5 Implementation of the Top Priority RD&D Needs – Green Group

RD&D Needs	Brief Description of Scope of the Need	Time Frame	Lead Participants	Supporting Participants	Next Steps
Standard Protocol developing for transacting DG	• Terminology and protocols for market integration of DG	Near-term (0-5 years)	FERC/ISOs	• Industry • WSCC • NERC	• DOE sponsors workshop among lead and supporting participants to develop terminology and protocols
Demonstrate a C&C system on a large scale (e.g., 50 MW, 1000 customer) DER network will value capture, wholesale, ancillary services and wireless benefits	• Capture and connect 1000 customers – 50 MW to represent diversity of generation and load • National DER technical center (e.g., NWTC)	Near-term (0-5 years)	Public/private partnership	• Many	• Determine DOE funding potential

KEY THEMES

6

THE field of communications and controls for distributed energy systems is new and evolving rapidly. There is a large pool of existing technologies that can be used to address anticipated needs, so care must be taken not to re-invent the wheel. Better functional specifications and workflow definitions are needed so that manufacturers, service providers, users, and others can have a better idea of how to make the best use of the existing suite of communications and controls technologies. Demonstration and field tests of DER systems – in both geographically concentrated and dispersed areas – are needed to help define better the functional specifications and the full range of communications and control system needs.

The biggest technical unknowns involve scale-up issues for large scale deployment, which is what is implied by DOE's goals for distributed energy resources over the next ten years. To the extent possible, the architecture of the system for deploying communications and controls under a large scale deployment scenario should be as open as possible to promote "plug&play" and inter-operability to the fullest extent possible. This will make it easier for customers to choose equipment from various manufacturers to suit their particular needs, and for them to have that equipment operate properly and reliably and with the least amount of hassle.

The other big unknowns are the uncertainties associated with the future structure of electricity and natural gas markets and regulations and whether or not the "rules of the game" will inhibit or aid distributed energy providers in capturing the full spectrum of potential benefits. If they aid providers, then a highly profitable value proposition will evolve and pull distributed energy devices, and the communications and controls needed to deploy them, into the marketplace rapidly. If they inhibit providers, then the distributed energy market will develop less rapidly and the technical issues surrounding large-scale deployment may be less important to resolve now.

In any event, there will be more entities involved in the delivery of distributed energy services than just the utilities. As the roles of the various entities become better defined over time, fragmentation and the lack of standardized approaches will continue to inhibit market development. The government needs to play a strong role to ensure the security of critical facilities and to address public and worker safety concerns. In addition, Federal efforts are needed to:

- support large scale demonstrations of distributed energy devices
- assist in defining the architecture and functional requirements for communications and controls systems
- assist in developing standard approaches to enable users to optimize their investments in energy equipment and services and in fostering a national "plug&play" environment
- conduct education and outreach on the potential benefits of distributed energy systems for state and local government agencies and public interest organizations
- strengthen ongoing research and development efforts through better technical coordination among government agencies and R&D projects cost-shared with industry, universities, and the national laboratories

Office of Power Technologies **U.S. Department of Energy**

WORKSHOP: Initiation of an Industry Roadmap on Communication and Control Technologies for Distributed Energy Resources Keystone Resort, Colorado September 25-26, 2001

Background

This Workshop is part of a technology roadmapping process to define research and development (R&D) needs and priorities for communication and control technologies for distributed energy resources. The resulting roadmap will set the R&D strategies and directions for the U.S. Department of Energy (DOE) Communications and Control Initiative (C&C) and will be known as the C&C Technology Roadmap. The Roadmap will include a broad range of distributed energy resources, defined as distributed generation systems (turbines, reciprocating engines, fuel cells, cooling/heating/power systems, and hybrids); renewable energy resources (solar, wind, geothermal, biopower, and hydropower); demand-side energy management (load control, diagnostics and prognostics, enterprise systems and grid-friendly equipment); fuel supply; energy storage; and transmission and delivery mechanisms.

The C&C Technology Roadmap process began with an Executive Summit in May 2001 that forged opinions on electricity valuation in the current economy and outlined information requirements with associated technical and non-technical barriers. The Summit also established a process for developing the Roadmap, starting with this Workshop to identify R&D needs. Other Technology Workshops will be held in the future to further refine and clarify these identified needs. Participants of this Workshop will receive a copy of the Summit report, which will also soon be available on the DER website (http://www.eren.doe.gov/der/). The C&C Technology Roadmap, scheduled for completion in April 2002, will be used as the basis for future budget planning and to initiate DOE solicitation(s) this year.

Objective

The Workshop objective is to set the framework for the C&C Technology Roadmap. This framework will:

- Discuss high-level strategic goals of the DOE Office of Power Technologies (OPT) on which communication and control technologies could have a significant impact
- Define functional objectives for communication and control technologies necessary to contribute to meeting the identified goals; define time-based, quantifiable metrics for each functional objective
- Define technology and application areas associated with each defined functional objective
- Determine research and development needs for communication and control technologies by assessing gap areas in identified technologies and applications

Who Will Participate

This Workshop will succeed through participation by:

Decision-makers in industry and Federal/state programs who can elaborate on strategic goals:

- Technology manufacturers and suppliers (distributed energy resources, controls, communication, power electronics, SCADA systems)
- Energy service providers, utilities, and their associations
- Industrial and commercial energy users

Technical Experts on communication and control technologies who have an R&D perspective, understand future technology scenarios, have experience applying these in a business context, and can define functional objectives, technologies, and applications needed to accomplish the strategic goals.

About the Workshop Sponsor

The DOE Office of Distributed Energy Resources (DER), within the OPT, was established with the mission of enabling new electricity generation capacity through advanced, environmentally clean, cost-effective distributed energy resources in order to meet the nation's energy challenges.

C&C, the Workshop sponsor, is a new program within the DER that is chartered to provide enabling communications and control technologies to optimize the off- and on-grid operations of distributed energy components, subsystems, and systems. Advanced, lower-cost communications and control devices are needed to reach the OPT goal of supplying 20% of U.S. electric capacity additions (~50 GW) with distributed energy systems by 2010. Existing R&D projects in the OPT and DER (such as those under the Energy Storage Systems, Transmission Reliability, Distributed Power, and Thermally Activated Technologies programs) will be coordinated while determining the scope of C&C activities.

The C&C charter strategy is to partner with industry in joint research, development, demonstration, and deployment (RD3) efforts, beginning with development of vision goals and technology pathways, through implementation of the C&C Technology Roadmap. This Workshop is a joint industry/government endeavor leading to the development of the Roadmap.

APPENDIX B: WORKSHOP AGENDA

TECHNOLOGY ROADMAP WORKSHOP
U.S. DEPARTMENT OF ENERGY

"Communications and Controls Systems for Distributed Energy Resources"
September 25 and 26, 2001
Keystone Conference Center, Keystone Colorado

DAY 1

7:30 AM	**Registration and Continental Breakfast**
8:30	**Opening Plenary Session**
9:30	**Discussion of U.S. DOE Goals and "Grand Technical Challenges"**
10:45	**Break**
11:00	**Breakout Session #1 – Functional Objectives for Communications and Controls Technologies**
12:30 PM	**Lunch**
1:30	**Breakout Session #2 – Communications and Control Technologies and Barriers**
3:00	**Break**
3:30	**Breakout Session #3 – RD&D Needs**
5:30 PM	**Adjourn Day 1**
7:00 PM	**Group Dinner**

DAY 2

8:00 AM	**Continental Breakfast**
8:30 AM	**Breakout Session #4 – Implementation of Top Priority RD&D Needs**
10:00	**Break**
10:30	**Closing Plenary Session**
11:30	**Adjourn**